Flexible, Smart, and Lethal

Adapting US SEAD Doctrine to Changing Threats

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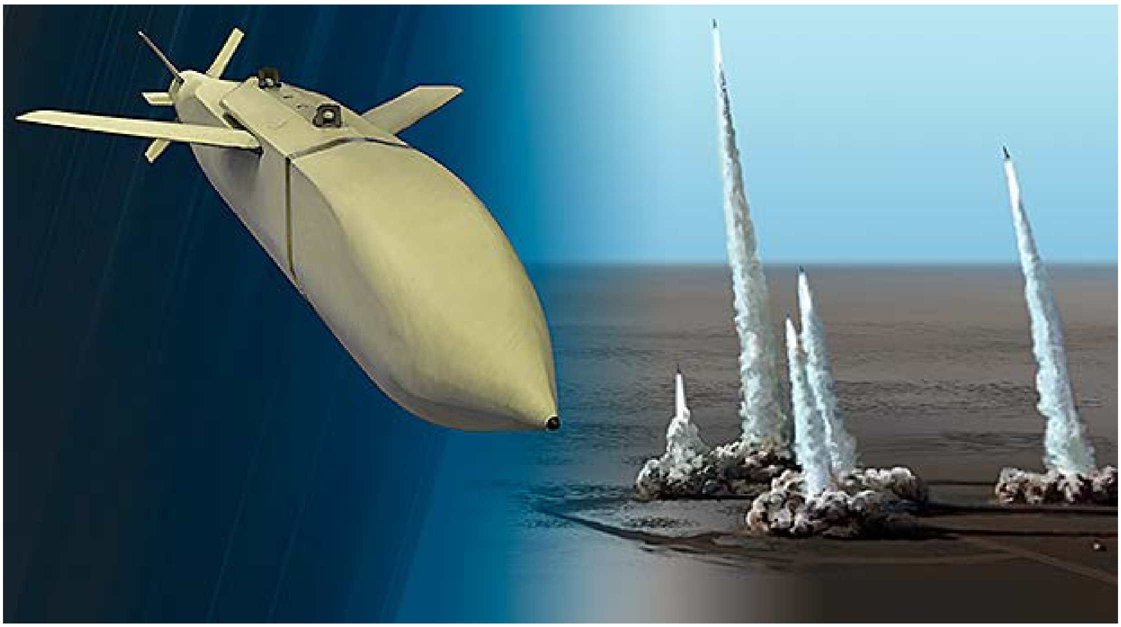

To gain total air supremacy in the modern age, air forces must not only render the enemy's air force ineffective but also contend with ground-based antiair defenses. Over the past two decades, the United States has acquired unquestioned air dominance in every major conflict that it has fought. This unrivaled success has prompted other nations to reassess their strategies and has pushed the development of an antiaccess/area-denial (A2/AD) doctrine that has become central to these strategies. This doctrine relies on sophisticated long-range weapons

designed to deny an opponent access to their territory. Of concern to an air force, adversaries will possess more sophisticated integrated air defense systems (IADS). Such systems include missiles that can fly farther and faster than those of previous generations; radars that can direct these missiles to a target with devastating accuracy while remaining more resistant to jamming; and command and control (C2) functions that are more refined than their predecessors. Furthermore, all of these components have mobile capabilities, making them more difficult to locate and target.

US airpower has achieved a high level of success in recent years. Indeed, air dominance is all but taken for granted by American policy makers and the American public. This presumption of superiority has likely contributed to the current gap between existing suppression of enemy air defenses (SEAD) doctrine and the capabilities being developed by potential adversaries. Ironically, the recent successes of Western air forces against air defenses in Libya, Iraq, and Kosovo have been dangerously misleading because they have encouraged policy makers to consider only situations in which legacy fighters and dated tactics have prevailed against outdated IADSs. The United States has not yet encountered the newest generation of these systems in combat, and many projections about how non-low-observable (LO) aircraft and older tactics will fare against them are bleak. Currently, US joint SEAD doctrine has not adapted to meet air defense threats in an A2/AD environment. In light of the foregoing, one must raise the following question: Has the United States developed the optimum doctrine for defeating a modern IADS with minimum losses to friendly forces?

This article makes five assumptions: (1) the IADS in the A2/AD environment described here will be insulated against cyber attack; (2) the adversary will make every attempt possible to complicate his opponent's electronic warfare capabilities; (3) LO aircraft will be able to reach their weapons-employment zone prior to being engaged by the assets they seek to destroy, and non-LO assets armed with standoff weapons will be able to produce that same effect; (4) point-defense weapons around critical IADS components will not be able to reliably stop incoming weapons from destroying or degrading them; and (5) if ground radars emit, they can be detected and located by friendly forces.

Current US Doctrine for the Suppression of Enemy Air Defenses

Joint Publication (JP) 3-01, *Countering Air and Missile Threats* (specifically, chap. 4, "Offensive Counterair Planning and Operations"), currently guides US SEAD doctrine.[1] Although the document acknowledges many of the complications presented by a modern IADS employed in an intelligent manner, it does not go far enough in describing how US SEAD doctrine must change to counter these threats.

JP 3-01 provides a very broad analysis of a potential IADS but in doing so touches on many aspects critical to understanding the system's threat in an A2/AD environment. Chapter 4 indicates that enemies will likely employ a highly decentralized C2 system with built-in redundancies that will make targeting C2 functions much more difficult than in the past. Moreover, it specifically mentions how the mobility

of an IADS has made targeting more problematic through the use of deception and constant repositioning: "SAM [surface-to-air missile] forces have become more mobile and lethal, with some systems demonstrating a 'shoot-and-move' time in minutes rather than hours or days."[2] This mobility will allow an adversary to significantly impede the ability of intelligence, surveillance, and reconnaissance (ISR) elements to find, fix, and track IADS components, thus slowing the entire kill chain. JP 3-01 also observes that a modern IADS will give "little warning prior to weapon engagements," affording aircrews less time to react to a previously unidentified threat.[3] Decreased aircrew reaction time will necessitate that plans become very fluid and able to shift on a moment's notice.

The joint publication makes note of the elements necessary to defeat a modern IADS but does an insufficient job of tying them all together into an acceptable doctrine to counter the emerging A2/AD threat. For example, when discussing deliberate and dynamic targeting with regards to offensive counterair, it states that

> OCA [offensive counterair] operations can be preemptive or reactive, and may be planned using deliberate or dynamic targeting. Missions using deliberate targeting are scheduled or on-call targets and included in the ATO [air tasking order] and rely on continuous and accurate intelligence to identify them at particular locations and times. Missions using dynamic targeting are unanticipated/unplanned targets, such as mobile TSTs [time-sensitive targets], that fall outside the ATO cycle and require immediate action. Minutes often define the timeline when these targets are vulnerable to attack. Those targets requiring immediate action cannot be effectively attacked unless responsiveness and flexibility is built into the targeting process and the ATO.[4]

Planning that incorporates decentralized execution is critical to any SEAD effort in an A2/AD environment because it allows the "target" and "engage" phases of the kill chain to be executed within the available temporal window. JP 3-01 correctly assesses the importance of deliberate on-call targets that will become the focus of any destructive SEAD measure in an A2/AD environment, and, as previously pointed out, "continuous and accurate intelligence" plays a crucial role. However, JP 3-01 does not offer an adequate synthesis of these concepts with regards to suppressing or destroying an IADS in an A2/AD environment.

The essential problem is that the document's section on "Suppression of Enemy Air Defenses" provides only a cursory glance at SEAD problems and offers nothing more than vague guidance on how to solve them. It is critical to recognize that no conflict will be the same as another (therefore, doctrine will require a high degree of flexibility), but the threats posed by a modern IADS employed in an effective manner should merit the formulation of a doctrine dedicated to defeating them.

The three categories of SEAD that seek to reduce attrition and create "more favorable conditions for friendly air operations" are (1) area of responsibility / joint operations area (AOR-/JOA-wide) joint air defense system suppression; (2) localized suppression; and (3) opportune suppression.[5] These categories, though still applicable in the A2/AD environment with regard to the desired effects of an air operation, do not adequately address the increased complexity of SEAD in this environment. The first category of SEAD—AOR-/JOA-wide air defense system suppression—"targets high payoff [air defense] assets that result in the greatest deg-

radation of the enemy's total system." The focus is on key C2 nodes associated with an IADS, having the intent "to destroy or disrupt the integration and synchronization of the enemy [air and missile defenses]."[6] Because of increasing redundancies and the mobility of C2 capabilities in a modern IADS, this category will become much harder to implement in an A2/AD environment, at least in a timely manner.[7] The second category of SEAD, localized suppression, is geographically confined to areas "associated with specific targets or transit routes for a specific time." Localized suppression is sometimes a subset of AOR-/JOA-wide air defense system suppression and is tied to the temporal domain as well as geography, making it relevant to an A2/AD environment; however, JP 3-01 does not discuss the more relevant elements of SEAD in such an environment.[8] The third SEAD category—opportune suppression—acknowledges most of the challenges posed by the mobility of a modern IADS as well as the need for rules of engagement (ROE) and planning to optimize their engagement; however, the tone of the discussion implies that this form of SEAD is largely unplanned and reactive to threats.[9] Reconciling the applicable elements of opportune suppression, as described in JP 3-01, with executing SEAD in an A2/AD environment calls for creation of a new category of suppression—one that combines the planned nature of localized suppression and the tactics of opportune suppression to become more proactive in engaging threats. As discussed here, this proposed new variant will be termed *planned opportune suppression*.

Such suppression would involve having on-station SEAD assets equipped to deal with threats known to be in the area—either unallocated threats or those likely to relocate between the time when plans are made and the mission is executed. Having SEAD assets available to engage threats as soon as they appear would add the inherent flexibility necessary to attack or suppress mobile targets that would probably move during the dynamic targeting process. For planned opportune suppression to be viable, flexible ROEs unique to SEAD would be necessary, and information would have to pass quickly from ISR assets to weapons platforms.

JP 3-01 identifies two alternatives for SEAD execution: destructive means and disruptive means. The former are explicitly defined as means that "seek the destruction of the target system or operating personnel," and disruptive means "temporarily deny, degrade, deceive, delay, or neutralize enemy surface [air defense] systems."[10] Disruptive means are further subdivided into active and passive means.[11] Neither of these definitions mentions using assets to coerce IADS operators into a course of action favorable to friendly forces, such as not emitting or moving components around so frequently that they cannot be set up to engage friendly aircraft. If destructive SEAD is sufficiently effective, then IADS operators will likely conclude that the only strategy that ensures their personal survival is not to emit at all (depending upon the situation.)

As currently discussed in JP 3-01, SEAD resources seem to represent little more than a catch-all list of anything that could potentially contribute to the SEAD mission.[12] Although it is necessary for commanders and planners to recognize everything available to them, LO aircraft and standoff weapons deserve specific mention as SEAD resources because of their utility in an A2/AD environment.

The Capabilities of a Modern Integrated Air Defense System

In the past few decades, the US military has faced only legacy export Soviet-era IADSs manned by poorly trained crews. These systems had mostly static components that were easy to track and avoid. Furthermore, missiles could manage only short ranges (relative to modern systems), and almost every technical detail about them was compromised.[13] The latest Russian and Chinese SAM systems—namely, the SA-10, SA-20, SA-21, and HQ-9—have missiles with greater range and maneuverability, upgraded radar systems, advanced data link and C2 systems, and the ability to pack up and move in a very short period of time.[14] In addition, well-trained crews are no longer as critical to the operation of an IADS. Advances in automation and computer technology have made many of the formerly sophisticated tasks very simple to perform if not completely handled by a computer.[15] The US military has yet to face an IADS with all of these attributes in combat.

The SA-21 Growler is one example of a system that will prove problematic to the US military.[16] Designated the S-400 Triumf by the Russians, the SA-21 is a further development of the SA-20 and has improved on the latter's already formidable capabilities in almost every respect. The SA-21 and its previous iterations were designed specifically to deal with US strategies for countering them. The ability to resist electronic attack, track increased numbers of targets, defeat incoming precision-guided munitions, and detect smaller radar signatures were all features deemed critical capabilities during the designing of the SA-21.[17]

By incorporating redundant communication methods in its C2 infrastructure, one can place the SA-21's C2 components as far as 100 kilometers (km) away from the radars or missiles themselves and can communicate by means of radio or landline links, including analog telephone cables.[18] The foregoing redundancies in communication make attacking these links, as outlined in current joint operational doctrine, extremely arduous.[19] Further, "all system components are carried by a self-propelled wheeled all-terrain chassis, and have autonomous power supplies, navigation and geo-location systems, communications and life support equipment."[20] This increased mobility serves to further complicate efforts to target any of these components since any intelligence necessary is, in effect, useful only for as long as the asset can verify that the component has not been relocated.

The various missiles employed by the system can cover a number of ranges out to 400 km and altitudes as high as 30 km. Export variants of the system are intentionally designed to destroy "opposing standoff jammer aircraft, AWACS [Airborne Warning and Control System]/AWEW&C [Airborne Early Warning and Control] aircraft, reconnaissance and armed reconnaissance aircraft, cruise missile armed strategic bombers, cruise missiles, Tactical, Theatre and Intermediate Range Ballistic Missiles, and any other atmospheric threats, all in an intensive Electronic Counter Measures environment."[21] Even if the system cannot perform as advertised, the extended range of its missiles will likely necessitate that high-value air assets are pushed further from the battlespace; more importantly, SEAD aircraft without LO characteristics or standoff weapons will be outranged.

In addition to the aforementioned capabilities, the system can be networked into older systems, thus improving their effectiveness. The 92N6 Gravestone engage-

ment radar utilizes computing power similar to that of Western active electronically scanned array (AESA) radars. Consequently, the Russians claim they can engage LO targets at greater ranges. The radar can track 100 targets in "track while scan" mode and six targets simultaneously for missile engagements. Equipped with a frequency-hopping radar as well as variable pulse-repetition frequencies and scan rates, the Gravestone was designed from the outset to defeat high-power active noise jammers. These radars and C2 components can also integrate with other IADSs, such as the SA-20.[22] US SEAD doctrine should recognize the fact that an SA-21 or any system sharing similar characteristics can change situations significantly.[23]

Proliferation of the Modern Integrated Air Defense System

Currently, Russia and China produce IADS components that are the most threatening to US aircraft, and both countries have expressed a willingness to proliferate these weapons all over the world. Although one may always debate the likelihood of armed conflict with either Russia or China, engaging with smaller regional powers or armed groups equipped with top-tier Russian and Chinese weapons is entirely within the realm of possibility, if not highly likely.[24] Regardless of who is confronted in a future conflict, the US military probably will find itself operating in an environment protected by an advanced IADS.

The United States has always sought to supply its allies with conventional arms as an instrument of foreign policy, and other states, including Russia and China, have done the same. Aside from economic gains, arms sales also foster relations between nations' militaries and ensure that allies are not placed at risk due to military transfers from an opposing power.[25] High-technology weapons sold by Russia and China are usually designed to counter US strategies and tactics, making them most desirable to countries that envision themselves in a future struggle with the United States. For example, China's much-touted A2/AD strategy relies on a sophisticated IADS and long-range, land-based weapons to prevent the United States from operating in areas near the Chinese coast.[26] As shown below, this same technology could be used by a different country to deny the United States access to its airspace, and the Chinese and Russians are all too willing to sell those systems to that nation.

A Congressional Research Service document entitled *Conventional Arms Transfers to Developing Nations, 2004–2011* points out that in the past decade, Russia and China have sold large numbers of weapons, including SAMs, to the developing world.[27] From 2004 to 2006, Russia ranked first in arms-transfer agreements to developing nations and second every year thereafter.[28] Most of these sales have involved sophisticated weapons such as missiles and aircraft.[29] From 2004 to 2007, Russia provided 6,340 SAMs to developing countries and 7,750 from 2008 to 2011.[30] China sold a considerably smaller number—only 530 from 2004 to 2007 and 780 from 2008 to 2011—but still a significant quantity compared to sales of Western countries.[31] These figures, although not representative of either the quality or exact type of system sold, typify Russia's and China's willingness to proliferate antiair weapons across the globe, whether for political or economic gain.

Even though the Chinese have not exported as many weapons as the Russians, they have supplied numerous missiles to developing countries but usually not entire missile systems.[32] Their recent decision to sell HQ-9 SAM systems to Turkey is indicative of a possible change in policy.[33] More worrisome is how even in the face of concerns about reverse engineering, Russian president Vladimir Putin approved the sale of Russia's most advanced missile system, the S-400 (SA-21 Growler), to China. This action will only continue the proliferation of IADS technology and could allow China to threaten aircraft operating over Taiwan and the Senkaku Islands (both potential flash points).[34]

Like the United States, Russia seeks to create additional long-term clients through a more flexible payment system and follow-on support for purchases. This support takes the form of "timely and effective service and spare parts for the weapon systems it sells."[35] In addition to technical support, Russia also offers training and expertise when it helps a customer set up an IADS, imparting tactics and doctrine to whoever is purchasing the system. These tactics, optimized for engaging LO aircraft, significantly increase the combat effectiveness of the party operating the system.[36]

A contemporary example of the proliferation of advanced air defense technology is the prospect of Russia selling the S-300 (SA-10 Grumble) to Iran and Syria.[37] After originally caving in to pressure from the West, Russia decided against selling the S-300 to Iran; however, after a visit to Tehran by Russian defense minister Sergei Shoigu in January 2015, it appears that the delivery might take place after all. During the meeting, Shoigu mentioned that Russia might be willing to sell the more capable SA-21 as well.[38] Earlier, Russia had also attempted to sell the shorter-range Tor (SA-15 Gauntlet).[39] Although the Iranians rejected the offer, Moscow's desire to continue sales of SAM systems even in light of international pressure is further proof of its intention to make systems available to any government willing to pay. The Russians also planned to sell the S-300PMU-2 (SA-20 Gargoyle) to the Bashar al-Assad regime in Syria. For various reasons, the delivery was never completed.[40] Nevertheless, Russia's willingness to send advanced antiaircraft weapons to such countries means that its most advanced systems will eventually proliferate to hostile governments.

Additionally, armed groups supported by a larger power can acquire advanced air defense weapons. Recently, separatist forces in eastern Ukraine allegedly have been sighted operating Russian Pantsyr-S1s (SA-22 Greyhound).[41] These systems are among the most modern in the Russian inventory. If they are being operated by separatist forces or even by the Russians themselves, their presence indicates that the Russians are willing to provide their top-of-the-line technology to foreign factions when it suits their interest. SA-10s, SA-20s, or even SA-21s could be deployed for use in the Ukraine conflict or in similar fighting. The United States and allied countries could just as easily find themselves in a battle with an armed group supported by a newer IADS or even a system manned by troops of a larger power.

Three New Assumptions

Formulation of effective doctrine for SEAD in an A2/AD environment calls for making three major assumptions about the nature of the IADS threat. First, almost all IADS components will be mobile and linked together in a system with considerable redundancy. Second, any non-LO aircraft or aircraft not equipped with standoff weapons will be outranged by an IADS. Third, an IADS will be inherently resistant to jamming and electronic attack. These three assumptions will provide a realistic basis for any doctrine necessary to execute SEAD in an A2/AD environment.

The first assumption has serious implications for the find, fix, track, and target phases of the kill chain. During Operation Allied Force, Serbian IADS operators dispersed their SAMs and functioned in an emission-control mode, making them very difficult to locate and attack.[42] Smart adversaries will have learned from previous American air operations and will structure their doctrine accordingly. For example, in contrast to the Serbian system, the Iraqi IADS during Operation Desert Storm was highly centralized and thus an easy center of gravity for coalition forces to target. Such control nodes, though hardened, were static and relatively simple to locate.[43] According to JP 3-01, "Fixed site, hardened facilities are usually easier to locate than mobile systems. Attacks against fixed sites can also be preplanned with appropriate weapons to increase the probability of kill."[44] Enemies of the United States have observed these two scenarios and have modeled their doctrine and strategies to optimize their ability to deny America and its allies their desired end state.[45] For this reason, modern IADSs have been specifically designed with mobility as a key capability for all of their components. Moreover, one should assume that those systems will be employed in a manner to disrupt SEAD operations that attempt to destroy or suppress them.

In *Kosovo and the Continuing SEAD Challenge*, Benjamin Lambeth comments that in Allied Force, "one problem with such [destruction of enemy air defenses] attempts was that the data cycle time had to be short enough for attackers to catch the emitting radars before they moved on to new locations."[46] To facilitate a shorter data cycle, one must have plans that allow for the rapid flow of information from ISR platforms and other information sources to strike platforms—and ROEs that allow those platforms to immediately engage threats as soon as they are located. The effects are twofold: (1) targets can be destroyed or significantly degraded, reducing the effectiveness of the system as a whole, and (2) given attainment of the first effect, the enemy is much more likely to limit emissions to prevent his system from being targeted. This tactic will produce the desired end state—specifically, the IADS will not be able to threaten friendly aircraft.

The mobility of IADSs means that the temporal domain will become more critical than ever. Ingress corridors that might have existed a few hours before may no longer be available as radars shift their location from the time they were located to when the strike package is scheduled to fly. Contending with this constantly changing air defense picture requires that an air tasking order incorporate a significant degree of flexibility.[47]

The second assumption, that an IADS will outrange any non-LO aircraft not equipped with standoff weapons, will affect the engage phase of the kill chain. If an

aircraft can be engaged by a SAM well before it can employ weapons against it, then there is no reason for the SAM operator not to fire on the aircraft. This fact is especially true with higher-accuracy SAMs that have probability of kills as high as .9 against manned aircraft.[48] If SEAD aircraft cannot strike SAMs before being engaged themselves (especially with a 90 percent probability of getting shot down during engagement), then enemy IADS operators have no incentive not to hit friendly aircraft. This assumption invalidates current theory, which assumes that SEAD aircraft will be able to engage SAMs before being engaged themselves.[49] In order for these aircraft to remain viable means of destroying IADS components, they must be either LO aircraft or be equipped with standoff weapons to remain outside the weapons-engagement zone of the SAM.

Friendly aircraft can attack a modern IADS in two ways: (1) by either reducing the range at which they can be detected or (2) extending the range of their weapons (or some combination of the two). LO aircraft, though not invisible to radar, will restrict the range at which they can be detected and tracked by radar, particularly at the higher frequencies found in a SAM's fire-control radars.[50] Doing so will allow them to get close enough to employ weapons against an IADS without being engaged by it first—something that legacy fighters without standoff weapons cannot do. This assumption is significant because it severely restricts the airframes that can engage IADSs. It will also affect the total number of airframes available for other missions. For example, every F-22 tasked with destroying IADS components will be taken away from performing defensive counterair or strike missions. Alternatively, non-LO aircraft equipped with standoff weapons, such as the AGM-154 joint standoff weapon, will be able to strike an IADS before being engaged.[51] But it is necessary to understand that regardless of the airframe or weapon tasked to conduct SEAD, that asset represents a military implement that could have been used for a different mission.[52] The specific airframe or weapon itself is not as important as producing the desired end state. SEAD doctrine must recognize the threat posed by the extended range of a modern IADS and apply the best ideas for defeating it.

The third assumption, that an IADS will be inherently resistant to jamming, will reduce the effectiveness of current disruptive suppression methods, if not render them irrelevant. Modern ground-based AESA radars have capitalized on improvements in solid-state and advanced off-the-shelf technology, coupled with improved processing, to become capable of countering hostile jamming.[53] In addition, frequency-agile radars (those that rapidly change the frequency of pulses sent out) are next to impossible to jam. However, this statement is true only as long as the pattern is genuinely random.[54] For example, the Russian Nebo SVU acquisition radar, which can be networked into an SA-20 or SA-21 system, employs frequency agility, beam-steering agility, and fully digital processing to severely complicate efforts to attack it electronically.[55] If an adversary makes every effort to prevent electronic disruption of his IADS, it is entirely possible that destructive SEAD will become the only usable tool to either destroy IADS components or coerce them into not engaging friendly aircraft.

Recommendation for Changes to Doctrine

Given the three underlying assumptions discussed previously, the US military should revise its joint SEAD doctrine to contend with advances in IADS technology and tactics. First, countering mobile IADS components requires adding a category of planned opportune suppression to JP 3-01 with a focus on flexible ROEs and mechanisms in place to allow for rapid dynamic targeting. Second, countering outranged air assets necessitates formally acknowledging LO aircraft and standoff weapons as SEAD resources. Third, countering jam-resistant radars calls for making destructive SEAD the focus of SEAD efforts against a modern IADS. If that is the case, then doctrine should acknowledge the psychological effects of destructive SEAD. Finally, because the temporal dimension of air warfare is becoming more important, air superiority will become more localized and could possibly be attained only for brief periods; consequently, air parity might become the norm in future conflicts.

Adding planned opportune suppression to JP 3-01 would grant maximum flexibility in attacking mobile IADS components by concentrating the strategy on "planned on-call targets" as they are defined in the document.[56] Planned opportune suppression would necessitate flexible ROEs and channels to allow intelligence from any source, not just ISR platforms, to be collected, analyzed, and disseminated to the proper platform in time to take action, thus expediting the dynamic targeting process. This process will lessen the time needed to run through the entire kill chain in order to cope with the shrinking temporal window within which a mobile IADS can be engaged once it is located. This type of suppression can be applied at any level, from local areas to throughout the AOR/JOA. Because a mobile IADS will constantly change locations, rigid planning will not be sufficient for suppressing it.

LO aircraft and standoff weapons should be added to the "resources" category in JP 3-01.[57] Against the longer ranges of a modern IADS, legacy SEAD weapons and platforms will not be able to reach their intended weapon-employment zones before being engaged by modern SAM systems. Conversely, LO aircraft and standoff weapons will be able to destroy or degrade these assets without being struck themselves. If SAMs cannot attack aircraft consistently before coming under attack themselves, then the enemy will have to adopt tactics to protect his IADS (and thus prevent it from engaging friendly aircraft) or risk losing the system.[58] Either outcome will have the effect of preventing the IADS from engaging friendly aircraft. For these reasons, LO aircraft and standoff weapons need to be recognized as critical SEAD resources when one plans an operation in an A2/AD environment.

Destructive SEAD will become the focus of SEAD efforts in this environment. However, JP 3-01 should recognize that physical degradation of IADS components or their destruction is not the only way to suppress an IADS through destructive means. With regards to the psychological effects of physical destruction, a 2004 RAND paper comparing SEAD to game theory declared that "successful U.S. capabilities, especially with respect to attacks on time critical targets, will often have the effect of causing the enemy to become paralyzed. The right move will be no move."[59] Successful employment of destructive SEAD against an enemy IADS will cause the adversary to react in a certain way based on how he is attacked. At some

point, effective destructive SEAD missions against an IADS will cause the enemy to alter his tactics to protect assets or risk losing them, thus forcing him to do nothing and producing the desired end state.[60] For this reason, JP 3-01 should devote more attention to the psychological effects of destructive SEAD.

Finally, if US assets are faced with an A2/AD threat, then air parity must become culturally accepted as the predominant level of air control. It is possible to attain limited air superiority in an A2/AD environment, but that situation probably will last only as long as the right assets are on station. An improperly supported strike package will become easy prey for an advanced IADS. Depending on the tactics used by an adversary, air superiority or air supremacy probably will not be attained until much later in the conflict—a scenario to which the US public and military are not accustomed. Moreover, carrying out operations in an A2/AD environment will require dedicating more assets to SEAD than would be necessary in other theaters. Although not the ideal application of air assets, such use of SEAD will likely be the only way of attaining the desired end state without unacceptable attrition of strike aircraft.

Good doctrine does not come from speculation alone. All of the foregoing claims should be tested in a safe laboratory environment, such as the Nevada Test and Training Range, before being granted the status of official doctrine. Such testing can verify the soundness of the doctrine without unnecessarily risking lives in an actual conflict.

Conclusion

As noted at the outset, the Department of Defense defines *doctrine* as "fundamental principles by which the military forces or elements thereof guide their actions in support of national objectives. It is authoritative but requires judgment in application."[61] The formulation of doctrine must not rely solely on past experience; it must be anticipatory as well. That said, changes to doctrine must still be verified by rigorous testing in a safe-to-fail environment. The modern IADS that will confront the US military in an A2/AD environment will prove fundamentally different than the system faced in previous conflicts. The mobility, extended range, and resistance to electronic attack of modern systems require the updating of US doctrine prior to performing combat operations in an A2/AD environment. To overcome these advances, joint SEAD doctrine must facilitate shrinkage of the time necessary to complete the kill chain against constantly moving IADS components. It can do so by creating SEAD-specific ROEs and establishing mechanisms that facilitate the rapid transfer of information to weapons platforms. One must further modify existing doctrine by formally recognizing LO aircraft and standoff weapons as critical resources for SEAD and giving destructive SEAD the central role in suppression of enemy air defenses. Taking a reactive approach to doctrine rather than a proactive one could cost war fighters their lives or impose unnecessary stress on planners attempting to tackle a situation for which current doctrine is inadequate.

Further research on updating SEAD doctrine could take different approaches to resolving a number of challenging issues. This article assumed that modern IADSs will be insulated against cyber attack—an appropriate assumption in a worst-case scenario but not necessarily true in an actual conflict. Even a closed network could

be attacked by a cyber weapon if an agent could covertly insert it into the system. Research concerning the integration of cyber weapons into SEAD doctrine deserves more attention. Furthermore, this article did not consider the possibility of using large numbers of remotely piloted platforms to overwhelm an enemy IADS. Many cheap, expendable systems could be a superior alternative to a few expensive manned platforms. Thus, employing large numbers of such aerial systems as SEAD assets is another area deserving of inquiry. In addition, researchers could examine the case for doctrine designed to degrade an enemy IADS by means of behind-the-lines attack, akin to the special operations teams employed in western Iraq immediately prior to the 2003 invasion that hunted down mobile Scud launchers.[62] The use of space assets to suppress air defenses is another possible topic of study not addressed here. Finally, research at the classified level would include sources that this article could not draw upon, offering greater insight into possible ways of refining SEAD doctrine.

Utilizing unclassified sources, this article has included recommendations for revising current SEAD doctrine. Warfare is dynamic, and previously unknown factors can always affect planning at all levels; however, doctrine must make every effort to reflect changes in the military capabilities of potential enemies. The increasingly sophisticated prowess of the modern IADS is a case in point. Given these capabilities, revision of US joint SEAD doctrine deserves serious attention. ✪

Notes

1. Joint Publication (JP) 3-01, *Countering Air and Missile Threats*, 23 March 2012, IV-1, http://www.dtic.mil/doctrine/new_pubs/jp3_01.pdf.
2. Ibid., IV-7.
3. Ibid.
4. Ibid., IV-8.
5. Ibid., IV-12.
6. Ibid., IV-13.
7. Christopher Bolkcom, *Military Suppression of Enemy Air Defenses (SEAD): Assessing Future Needs*, CRS Report for Congress RS21141 (Washington, DC: Congressional Research Service, 24 January 2005), 3, http://www.fas.org/man/crs/RS21141.pdf.
8. JP 3-01, *Countering Air and Missile Threats*, IV-13–IV-14.
9. Ibid., IV-14.
10. Ibid., IV-13. Most of the disruptive means mentioned will be ineffective against a modern IADS.
11. Ibid.
12. Ibid., IV-12–IV-13.
13. Carlo Kopp, "The Perfect Fighter: Does It Exist, Do We Need It, Can We Afford It?," *Flight Journal*, 16 July 2012, 46.
14. Lt Col Ralph J. Waite IV, "The Fragility of Air Dominance," research paper (Carlisle Barracks, PA: US Army War College, 2012), 16, http://oai.dtic.mil/oai/oai?verb=getRecord&metadataPrefix=html&identifier=ADA561936.
15. Lt Col Michael Martindale, interview by the author, US Air Force Academy, 12 January 2015.
16. It is worth noting that the SA-21 is currently the most capable IADS used operationally and that although other systems possess similar characteristics (e.g., the SA-10), they are less capable.
17. Dr. Carlo Kopp, "Almaz-Antey 40R6 / S-400 Triumf Self Propelled Air Defence System / SA-21," Technical Report APA-TR-2009-0503, Air Power Australia, 27 January 2014, http://www.ausairpower.net/APA-S-400-Triumf.html.
18. Ibid.

19. JP 3-01, *Countering Air and Missile Threats*, IV-13.
20. Kopp, "Almaz-Antey 40R6 / S-400 Triumf."
21. Ibid.
22. Ibid.
23. Since the Russians intend to export this system, their claims of its capability are likely exaggerated to a certain degree.
24. Benjamin S. Lambeth, "Lessons from Modern Warfare: What the Conflicts of the Post–Cold War Years Should Have Taught Us," *Strategic Studies Quarterly* 7, no. 3 (Fall 2013): 63.
25. Richard F. Grimmett and Paul K. Kerr, *Conventional Arms Transfers to Developing Nations, 2004–2011*, CRS Report for Congress R42678 (Washington DC: Congressional Research Service, 24 August 2012), 1, http://www.fas.org/sgp/crs/weapons/R42678.pdf.
26. Andrew Krepinevich, Barry Watts, and Robert Work, *Meeting the Anti-access and Area-Denial Challenge* (Washington, DC: Center for Strategic and Budgetary Assessments, 2003), 93.
27. Grimmett and Kerr, *Conventional Arms Transfers*. The authors make little mention of radars or C2 infrastructure to accompany these weapons, but it is highly likely that these components have been sold as well.
28. Ibid., 6.
29. Ibid., 9.
30. Ibid., 64. It is important to note that these numbers are not representative of either the quality of the missiles or the training of their operators and that they include all ground-based SAMs (everything from man-portable air defense systems to large radar-guided missiles).
31. Ibid.
32. Ibid., 10.
33. The HQ-9, like most Chinese weapons, is a reverse-engineered S-300. It more or less possesses the capability of an SA-20. Denise Der, "Why Turkey May Not Buy Chinese Missile Systems After All," *Diplomat,* 7 May 2014, http://thediplomat.com/2014/05/why-turkey-may-not-buy-chinese-missile-systems-after-all/.
34. Zachary Keck, "Putin Approves Sale of S-400 to China," *Diplomat,* 11 April 2014, http://thediplomat.com/2014/04/putin-approves-sale-of-s-400-to-china/.
35. Grimmett and Kerr, *Conventional Arms Transfers*, 6.
36. Igor Sutyagin, "Air Defence—the Opposite Side of Air Power" (paper presented at Chief of the Air Staff RAF Air Power Conference, Royal United Services Institute, London, 18 July 2013).
37. Jeremy Binnie, "Iranian Official Claims Progress of S-300 Replacement," IHS Jane's 360, 28 April 2013, http://www.janes.com/article/12183/iranian-official-claims-progress-on-s-300-replacement.
38. Thomas Grove, "Russia May Send S-300 Missile System to Iran—Media," Reuters, 20 January 2015, http://www.reuters.com/article/2015/01/20/us-russia-iran-missiles-idUSKBN0KT1K420150120.
39. Jeremy Binnie, "Iran Rejects Russia's Offer to Replace S-300 with Short-Range Tor," IHS Jane's 360, 11 June 2013, http://www.janes.com/article/13625/iran-rejects-russia-s-offer-to-replace-s-300-with-short-range-tor.
40. Jeremy Binnie, "Russia Cancels Syrian S-300 Deal," IHS Jane's 360, 13 August 2014, http://www.janes.com/article/41819/russia-cancels-syrian-s-300-deal.
41. Nicholas de Larrinaga, "Russian TOS-1 and Pantsyr-S1 Systems Reported in East Ukraine," *IHS Jane's Defence Weekly*, 4 February 2015, http://www.janes.com/article/48685/russian-tos-1-and-pantsyr-s1-systems-reported-in-east-ukraine.
42. Benjamin S. Lambeth, *Kosovo and the Continuing SEAD Challenge* (Santa Monica, CA: RAND Corporation, 3 June 2002), 2.
43. Thomas Withington, *Wild Weasel Fighter Attack: The Story of the Suppression of Enemy Air Defences* (South Yorkshire, UK: Pen & Sword Aviation, 2008), 150–53.
44. JP 3-01, *Countering Air and Missile Threats*, IV-5.
45. Krepinevich, Watts, and Work, *Meeting the Challenge*, i, 12.
46. Lambeth, *Continuing SEAD Challenge,* 6.
47. Alternatively, critical components such as C2 vehicles can be positioned in areas difficult to strike without an undesirable secondary effect (e.g., a mosque, crowded market, or hospital). Doing so would further complicate the targeting process because any attempt to destroy the IADS would either

have to be planned in such a way to mitigate the possibility of civilian casualties or accept the possibility of harming noncombatants.

48. Kopp, "Almaz-Antey 40R6 / S-400 Triumf."

49. Thomas Hamilton and Richard Mesic, *A Simple Game-Theoretic Approach to Suppression of Enemy Defenses and Other Time Critical Target Analyses* (Santa Monica, CA: RAND Corporation, August 2004), vii.

50. Rebecca Grant, *The Radar Game: Understanding Stealth and Aircraft Survivability* (Washington, DC: Mitchell Institute Press, September 2010), 39.

51. "AGM-154 Joint Standoff Weapon (JSOW)," Raytheon Company, accessed 11 March 2015, http://www.raytheon.com/capabilities/products/jsow/.

52. Despite the overlap between SEAD capabilities and strike (making it possible for an aircraft to perform both missions simultaneously), it is important to recognize that a weapon employed against one target cannot be used against another. For example, if a SEAD aircraft is suddenly tasked to attack an armored column, it will be unable to respond to an air defense threat that pops up later. The commander must be able to recognize the mission that has more value (a fact that, of course, will vary on a case-by-case basis).

53. Waite, "Fragility of Air Dominance," 18.

54. George W. Stimson, *Introduction to Airborne Radar*, 2nd ed. (Mendham, NJ: SciTech Publishing, 1998), 457–58.

55. Dr. Carlo Kopp, "NNIIRT 1L119 Nebo SVU / RLM-M Nebo M: Assessing Russia's First Mobile VHF AESAs," Technical Report APA-TR-2008-0402, Air Power Australia, 27 January 2014, http://www.ausairpower.net/APA-Nebo-SVU-Analysis.html.

56. JP 3-01, *Countering Air and Missile Threats*, IV-10.

57. Ibid., IV-13.

58. Hamilton and Mesic, *Simple Game-Theoretic Approach*, 11.

59. Ibid., 53.

60. One must acknowledge, however, that psychological effects are subject to many variables, such as how much the enemy values his IADS assets or how long either side believes that combat operations will last.

61. JP 1-02, *Department of Defense Dictionary of Military and Associated Terms*, 8 November 2010 (as amended through 15 January 2016), 71, http://www.dtic.mil/doctrine/new_pubs/jp1_02.pdf.

62. Benjamin S. Lambeth, *The Unseen War: Allied Air Power and the Takedown of Saddam Hussein* (Annapolis, MD: Naval Institute Press, 2013), 71–72.

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